

# **Energy Batteries for EVs and PHEVs: Candidate Technologies and Issues**

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## What defines an ‘Energy Battery’?

- Sized by an energy requirement and designed to have a high Wh/kg
- The power requirement is modest and usually does not size the battery
- The battery is deep discharged in regular use (60-70% SOC)
- High cycle life - 2000-3000 cycles
- Low Cost \$/kWh - less than \$250/kWh
- Safety, thermal management, and monitoring are critical

## Candidate Technologies

- Nickel metal hydride
- Lithium-ion
- Lithium polymer
- Sodium metal chloride (Zebra-300 degC)

## Battery characteristics

- Energy density Wh/kg, Wh/L
- Pulse power density W/kg, W/L
- Calendar and cycle life
- Thermal management
- Safety and monitoring requirements
- Cost \$/kWh, \$/kW

## Issues

- Trade-offs between energy density, power density, cycle life, safety, and cost
- Effect of discharge/charge use patterns on cycle life
- Safety/failure modes and monitoring requirements
- Cost, Cost, and Cost in high production

## Baseline characteristics of EV and HEV batteries

Battery type	Wh/kg	W/kg	\$/kWh
<b><u>Lead-acid</u></b>			
Energy bat.	35	200	150
Power bat.	25	315	300
<b><u>NickelMetHyd</u></b>			
Energy bat.	75	200	500
Power bat.	45	800	800
<b><u>Sodium metal chloride</u></b> (Zebra -300 deg C)			
Energy bat.	100	200	400
<b><u>Lithium-ion</u></b>			
Energy bat.	120	400	500
Power bat.	75	1200	800
<b><u>Ultracapacitors</u></b>			
Carbon/carbon	4.5	1500	\$10/Wh

## Agenda for the session

1. Andrew Burke (10 min), Energy batteries for EVs and PHEVs: Candidate Technologies and Issues, ITS-Davis
2. Tien Duong (20 min.), Review of the DOE/USABC battery program, US DOE
3. Michael Andrew (20 min.), Lithium-ion: Enabling a Spectrum of Alternate Fuel Vehicles, Johnson Controls
4. Mark Duvall (20 min.), Battery considerations and test results for lithium-ion batteries in the Sprinter PHEV, EPRI
5. Andrew Chu (20 min.), Design considerations and the status and future plans for lithium-ion batteries using iron phosphate in the cathode, A123 Battery Co.
6. Evan House (20 min.), Status of lithium-ion batteries using lithium titanate in the anode (safety, fast charging, and long cycle life), Altrairnano